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ORIGINAL CONTRIBUTIONS

Combined Sleeve Gastrectomy with Liver Transplant in Patients with Obesity: a Feasibility Study

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Abstract

Background Nonalcoholic steatohepatitis (NASH) associated with obesity is one of the leading causes of liver failure requiring transplant, yet guidelines for the management of obesity in these scenarios are not always followed. In order to decrease incidence of NASH in the new liver, we studied the feasibility of simultaneous liver transplant and bariatric surgery.

Materials and Methods We retrospectively identified patients who underwent simultaneous liver transplant and sleeve gastrectomy at our hospital site between November 24, 2019, and April 14, 2022. Demographics, surgical data, postoperative adverse events, and weight loss data were collected.

Results Ten patients met inclusion criteria. Mean body mass index (BMI) at the time of transplant was 43.1 ± 5.3 kg/m^2, and mean length of hospital stay was 10.8 ± 5.22 days. Within 30 days after surgery, 7 patients reported adverse effects, and 2 were readmitted. Mean BMI at 6-month follow-up was 30.6 ± 2.5 kg/m^2. Mean percentage excess weight (in pounds) loss was $48.1 \pm 11.4\%$, $58.6 \pm 8.9\%$, and $66.1 \pm 15.3\%$ at 3-, 6-, and 12-month follow-up, respectively. Three patients had an increase in weight at 12-month follow-up when compared to 6-month follow-up. Most patients required fewer comorbidity-related medications, and none reported adverse effects related to sleeve gastrectomy.

Conclusions Bariatric surgery at the time of liver transplant is safe and has minimal adverse effects. Results include substantial postoperative weight loss, improvement in comorbidities, and decreased risk of NASH in the new liver. Further studies with larger cohorts are required to confirm the findings of this study.

Keywords Bariatric surgery · Liver transplantation · Obesity · Sleeve gastrectomy

Abbreviations

%EWL	Percentage excess weight loss
BMI	Body mass index
NASH	Nonalcoholic steatohepatitis

Key Points

Obesity is both a major cause and a common adverse effect of liver transplant.
Simultaneous liver transplant and sleeve gastrectomy are feasible and safe.
It also effectively reduces body weight and obesity-associated comorbidities.

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Introduction

Currently, 35% of the US population is obese, and 2030 projects an increase to 51.1%, with 16 to 18% of the total health care cost attributable to obesity alone (1). With the increasing prevalence of obesity, incidence rates of nonalcoholic fatty liver disease and nonalcoholic steatohepatitis (NASH) are also rising. Although the global prevalence of nonalcoholic fatty liver disease is 25.24%, in the USA, it is 30% (2, 3). Similarly, NASH has increased to 5%, of which almost 20% of patients have shown progression to end-stage liver disease (3). NASH is currently the second most common indication for liver transplant and will soon become the most common (4).

Patients with severe obesity are less likely to be placed on the transplant waitlist and undergo transplantation. Previous analysis report higher waitlist mortality (hazard ratio = 1.16) in patients with severe obesity (5). Post–liver transplant obesity-related adverse effects include recurrence of NASH and development of other comorbidities like metabolic syndrome, heart disease, and cancer, which have resulted in suboptimal long-term outcomes (6, 7). Hence, a collaboration between the bariatric surgeon and the transplant team is necessary to manage patients with obesity requiring liver transplant.

Obesity is both a major cause and a common adverse effect of liver transplant (8), yet guidelines for the management of obesity in these scenarios are not always followed. Although lifestyle modifications and medical treatment are the primary approach to weight loss, they might be insufficient in many patients. Recent evidence also suggests that bariatric surgery, compared to nonsurgical treatment of obesity, leads to greater weight loss and higher remission rates of type 2 diabetes and metabolic syndrome (9).

Few studies have addressed the choice of technique for bariatric surgery and its timing with respect to liver transplant. We present a cohort of 11 patients with class III obesity (BMI ≥ 35 kg/m^2) who underwent simultaneous liver transplant and sleeve gastrectomy.

Methods

We retrospectively identified adult patients who underwent simultaneous liver transplant and bariatric surgery at our hospital site between November 24, 2019, and April 14, 2022.

Clinical characteristics evaluated include sex; age; obesity-related comorbidities such as type 2 diabetes, hypertension, hyperlipidemia, and obstructive sleep apnea; indication for transplant; BMI at the time of transplant; and post-operative weight loss. Post-operative weight loss was assessed from BMI and percentage excess weight loss (%EWL) at 3-, 6-, and 12-month follow-ups.

Post-operative outcomes up to 30 days after surgery and follow-up records at 3-, 6-, and 12-month were also reviewed. Comorbidity control was assessed based on changes in medications before and after surgery. During follow-up visits, patients were evaluated by the bariatric and transplant teams, a nutritionist, and a physical therapist. The patients were counseled on dietary habits and exercise routine.

Categorical variables were summarized as counts (percentages), and continuous variables were reported as means (standard deviations). The analysis was done using the BlueSky Statistics™.

Surgical Technique

Patients selected by the transplant team to undergo bariatric procedure were assessed by the bariatric team for eligibility to undergo bariatric surgery, based on the National Institutes of Health guidelines on obesity (10), and completed the bariatric surgery education. All patients were enrolled in a noninvasive pretransplant weight loss program. When the patients' model for end-stage liver disease (MELD) scores were high enough, they were scheduled for orthoptic liver transplant, and the decision was made to perform a simultaneous sleeve gastrectomy. All patients consented to undergo simultaneous procedures.

Once all vascular anastomoses for the transplant were completed, the bariatric team was called in and the transplant team left. The short gastric vessels and the gastroepiploic arcade were taken down starting 5 cm from the pylorus to the gastroesophageal junction using a LigaSure device (Medtronic). Then, the stomach was fully mobilized along the greater curvature. A 40F bougie was introduced from the patient's mouth to the pylorus, with the vertical gastrectomy started at 5 cm from the pylorus. The first few loads, usually 2 to 3 depending on the tissue thickness, were black. Following the black loads, the gastrectomy was continued with purple loads. Upon completion, the gastrectomy specimen was sent for pathology. The suture line was then oversewn with 3–0 polydioxanone sutures in a running fashion from the gastroesophageal junction to the antrum. After removing the bougie, the suture line was sutured to the omentum in several areas to avoid kinking. Finally, an intraoperative esophagogastroduodenoscopy (EGD) was performed.

Once the sleeve gastrectomy was finished, the transplant team returned to the OR and performed the biliary anastomosis.

Sleeve gastrectomy added a mean of 45 min to the total operative time.

Results

Ten patients were included in our study. Patients' demographics, comorbidities, and post-operative complications are listed in Table 1. Outcomes related to bariatric surgery are listed in Tables 2 and 3.

Mean age at the time of transplant was 58.6 ± 7.23 years. Three (30%) patients were female, and 7 (70%) were male. Mean BMI at transplant was 43.1 ± 5.3 kg/m^2, and mean highest lifetime weight was 324 ± 66.8 lbs. Eight (80%) patients had hypertension, 6 (60%) had diabetes, and 7 (70%) had obstructive sleep apnea. The most common indication for liver transplant was NASH (70%). The remaining 3 (27.2%) patients had hepatitis C-induced end-stage liver disease.

Mean length of hospital stay was 10.8 ± 5.22 days. The most common perioperative complications were transient increase in creatinine and gastroesophageal reflux symptoms. Seven patients had early post-operative complications (< 30 days after surgery), 2 of whom were readmitted for right hepatic artery stenosis and unspecified congestive

Table 1 Demographic and comorbidity information for patients that underwent simultaneous liver transplant and sleeve gastrectomy

Case no	Age (years)	Sex	BMI at Tx (kg/m^2)	MELD score	Comorbidities	LOS (d)	30-day post-op complications
1	64	M	35.5	14	HTN, GERD, OSA, CKD, hypothyroidism	9	Atrial fibrillation
2	57	F	49.6	30	DM, HTN, GERD, HLD, OSA, bradycardia with pacemaker, hypothyroidism	24	AKI, TIA
3	63	M	41.6	19	HTN, GERD, hypothyroidism	12	AKI
4	59	M	43.2	24	DM, HTN, GERD, HLD, OSA, emphysema	6	-
5	68	F	37.7	26	GERD, Endometrial CA, CKD	13	AKI, delirium, right kidney capsular bleed
6	64	F	47.5	22	DM, HTN, GERD, HH, breast cancer, endometrial cancer, hypothyroidism, acute bacterial endocarditis	12	-
7	53	M	45.8	13	DM, HTN, GERD, OSA, CKD, pheochromocytoma, psoriasis	8	AKI
8	61	M	38.1	6	DM, GERD, HH, OSA, CHF, COPD	9	Right hepatic artery stenosis
9	43	M	41.5	32	DM, HTN, GERD, OSA, RA, PUD	6	-
10	54	M	50.7	23	HTN, OSA, CKD, HH, PVT	9	Splenic infarct
Mean (SD)	58.6 ± 7.23		43.1 ± 5.3	21		10.8 ± 5.22	

Abbreviations: F female, *M* male, *BMI* body mass index, *MELD* model for end-stage liver disease, *HTN* hypertension, *DM* diabetes mellitus, *GERD* gastroesophageal reflux, *OSA* obstructive sleep apnea, *CKD* chronic kidney disease, *HDL* hyperlipidemia, *CHF* congestive heart failure, *COPD* chronic obstructive pulmonary disease, *RA* rheumatoid arthritis, *PUD* peptic ulcer disease, *STEMI* ST-elevation myocardial infarction, *HRS* hepatorenal syndrome, *HH* hiatal hernia, *LOS* length of stay, *AKI* acute kidney injury, *TIA* transient ischemic attack

Table 2 BMI and %EWL in patients who underwent simultaneous liver transplant and sleeve gastrectomy

Case no	BMI at surgery	BMI at 6-month F/U	%EWL at 3-month F/U	%EWL at 6-month F/U	%EWL at 1-year F/U
1	35.5	27.1	38.59	68.36	78.83
2	49.6	30.5	58.38	63.48	52.17
3	41.6	32.4	51.58	52.39	82.54
4	43.2	30.8	56.36	69.51	74.51
5	37.7	28.35	44.18	51.65	73.63
6	47.5	29.9	66.09	64.21	59.30
7	45.8	35.8	37.51	44.17	41.70
8	38.1	30.26	38.26	51.36	NA
9	41.5	30.1	58.28	62.16	NA
10	50.7	NA	33.33	NA	NA
Mean (SD)	43.1 ± 5.3	30.6 ± 2.5	48.1 ± 11.4	58.6 ± 8.9	66.1 ± 15.2

The unit of weight used to calculate BMI and %EWL was pounds

Abbreviations: %EWL percentage excess weight loss, *BMI* body mass index, *F/U* follow-up, *NA* not available

heart failure, respectively. Sleeve gastrectomy did not prolong total length of hospital stay, and none of the patients reported adverse effects related to this intervention.

Follow-up data at 3, 6, and 12 months was available for 10, 9, and 7 patients, respectively. The date the surgery was performed explains the missing follow-up information, as one patient was operated on in April 2022 and two others by the end of 2021 (Reviewer #1, Comment 4).

Mean BMI was 32.9 ± 3.8 kg/m^2, 30.6 ± 2.5 kg/m^2, and 29.4 ± 4.7 kg/m^2 at 3-, 6-, and 12-month follow-up, respectively. Mean %EWL was 48.1 ± 11.4%, 58.6 ± 8.9%, and 66.1 ± 15.3% at 3-month, 6-month, and 1-year follow-up,

Table 3 Weight and TBWL in patients who underwent simultaneous liver transplant and sleeve gastrectomy

Case no	Weight (lbs) at surgery	Weight (lbs) at 3-month F/U	TBWL (lbs) at 3-month F/U	Weight (lbs) at 6-month F/U	TBWL (lbs) at 6-month F/U	Weight (lbs) at 1-Year F/U	TBWL (lbs) at 1-month F/U
1	262	227	35	200	62	190.5	71.5
2	298	197.3	100.7	188.5	109.5	208	90
3	307	237	70	235.9	71.1	195	112
4	346	256	90	235	111	227	119
5	187	146.8	40.2	140	47	120	67
6	260	161.2	98.8	164	96	171.3	88.7
7	328	269.6	58.4	256.4	71.6	260.4	67.6
8	236	199.5	36.5	187	49	NA	NA
9	290	215	75	210	80	NA	NA
10	324	264.6	59.4	NA	NA	NA	NA
Mean (SD)	283.8 ± 48.21	217.4 ± 41.89	66.4 ± 24.83	201.87 ± 37.01	77.47 ± 23.86	196.03 ± 44.1	87.97 ± 21.09

Abbreviations: TBWL total body weight loss, *F/U* follow-up, *NA* not available

respectively. Three patients showed an increase in weight at 1-year follow-up when compared to 6-month follow-up.

Of the 10 patients who were followed up for 3 months or more, 2 (20%) showed resolution of hypertension, 4 (40%) had their hypertension medication requirement reduced, and 3 (30%) had their diabetes treatment requirements reduced.

Discussion

Obesity has become not only a major cause of liver disease and transplant but also a major post-transplant adverse effect (6, 7). The aim of this study was to evaluate the feasibility of simultaneous liver transplant and bariatric surgery. The best time for bariatric surgery in liver transplant patients has been debated for years now, yet the literature is limited. Each setting has its advantages and disadvantages.

The main barrier to bariatric surgery before transplant is that patients are often too sick. Although there is evidence supporting positive outcomes for bariatric surgery in the setting of nonalcoholic fatty liver disease and NASH (8), it has also been reported that patients with decompensated cirrhosis who undergo bariatric surgery have 30-day mortality of 16.7% (11). Therefore, portal hypertension and cirrhosis should contraindicate bariatric surgery prior to transplant. Other factors to be considered include MELD score, platelet counts, international normalized ratio (INR), and bilirubin level, all of which can impact the outcome. Furthermore, a lower BMI at the time of the transplant may help reduce wound-related adverse effects and NASH recurrence (12).

Bariatric surgery at the time of transplant is a newer approach, and to our knowledge, only two studies have been published (13, 14). A major advantage of a simultaneous approach is a single surgical intervention with minimal increase in total operative time. This approach also helps avoid technical difficulties related to adhesions and changes in anatomy from previous abdominal surgery. The studies mentioned above also report positive long-term outcomes due to consistent post-operative weight loss and improvement in comorbidities (13, 14). A difficulty of simultaneous surgery is the availability of a bariatric surgeon at the time of transplant, which is often scheduled with short notice. Additionally, combining a bariatric surgery, especially sleeve gastrectomy, with transplant adds the potential risk of post-operative dehydration. Also, a gastric leak from bariatric surgery can negatively affect the outcome of the transplant.

Bariatric surgery after liver transplant has been well studied compared to the above approaches. Cheng and Elli (15) reported that it was safe to perform bariatric surgery after orthoptic solid organ transplant, including liver. According to the study, bariatric surgery led to significant weight loss and improvement of comorbidities but was also associated with a higher incidence of post-operative complications and readmission rates. Technical difficulties during bariatric surgery after transplant are due to adhesions and bleeding. Additionally, Lin et al. reported a 33.3% complication rate, with some patients requiring conversion to a Roux-en-Y esophagojejunostomy, which can result in malnutrition, a major adverse effect (6). Nonetheless, bariatric surgery after transplant is an option for patients who develop post-transplant obesity, especially if they were not obese prior to transplant.

Sleeve gastrectomy was the operation of choice because of its simplicity, effectiveness in weight loss (16), and short operative time. Additionally, during a simultaneous approach, it is important to maintain access to the biliary system to avoid adverse effects related to malabsorption, which is not possible with a Roux-en-Y gastric bypass.

Sleeve gastrectomy also leaves Roux-en Y gastric bypass as an option if redo bariatric surgery is required.

Limitations of our study include a small retrospective study population and lack of long-term follow-up. To our knowledge, there are no studies providing a direct comparison of outcomes of bariatric surgery before, during, or after liver transplant.

Declarations

Conclusion Simultaneous liver transplant and sleeve gastrectomy are feasible, safe, and do not add risks or adverse events to regular liver transplantation surgery. This combined procedure also effectively reduces body weight and controls obesity-associated comorbidities. More studies with larger cohorts are needed to evaluate long-term outcomes of combined surgery so that future programs providing simultaneous bariatric surgery to obese patients undergoing liver transplant can be developed.

Ethical Approval
For this type of study, formal consent is not required.

Informed Consent Informed consent does not apply.

Conflict of Interest The authors declare no competing interests.

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